SUPPLEMENTARY SOIL SURVEY IN THE VICINITY OF THE HIGHLAND CREEK SEWAGE TREATMENT PLANT INCINERATOR: SCARBOROUGH - 1989

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Background

In November 1987 the Phytotoxicology Section conducted a survey in the vicinity of the Highland Creek Sewage Treatment Plant Incinerator (HCSTPI) to determine if stack emissions from this source had contaminated soil in the surrounding residential area with heavy metals, dioxins (PCDDs), furans (PCDFs) or PCBs. The results of this survey were released in an MOE public report in March 1989. The report concluded that emissions from the HCSTPI have had no measurable impact on the soil of residential properties. However, PCDDs and PCDFs, including some tetra-chlorinated dioxins, were detected in a few soil samples.

The report was critically reviewed by an AD HOC committee of local property owners. The committee's written critique disagreed with the reports' conclusions. At a meeting between the committee and MOE staff held on May 15, 1989, Phytotoxicology Scientists agreed to re-sample soil from the three sites where tetra-chlorinated dioxins were detected and to conduct additional soil sampling for inorganic contaminants. This report summarizes the results of the supplementary HCSTPI soil survey.

Sample Strategy

In the original HCSTPI soil survey tetra-chlorinated dioxins were detected on three residential properties: (original) survey Site 7 on Colonel Danforth Trail, Site 8 on Pepper Tree Drive, and Site 3 on Satok Terrace. Replicate soil samples were collected from each of these sites on May 29, 1989, as part of the supplementary HCSTPI survey. Each sample was collected as close as possible to the original soil sample, plus additional samples were obtained from elsewhere on the properties. Also, at Site 3 and Site 7 a soil sample (Site 3-4 and Site 7-4 in the attached tables) was collected from the mid-slope of the ravine behind these two residential properties. At Site 8 an additional sample (Site 8-4) was collected from the centre of the playing field located immediately east of Pepper Tree Drive and south of Lawrence Avenue East. These latter three samples were obtained because they were approximately the same distance from the HCSTPI as the respective residential properties but they should be free of contaminants which may be associated with residential land use at those sites.

The soil samples collected from all of these areas were analyzed for the T_4, P_5, H_6, H_7 and O_8 congener groups for both PCDDs and PCDFs, the 2,3,7,8-T_4CDD dioxin isomer and total PCBs.

In addition to the sampling for organic analysis, an inorganic sampling program also was

conducted. Triplicate soil samples were collected every 250 m along two 3000 m long transects, one running to the NE and the other to the NW from the HCSTPI. The NE transect originates at the HCSTPI stack and falls along a line crossing Port Union Road at HWY 401. The NW transect falls along a line from the stack to the intersection of Old Kingston Road and Manse Road. These samples were 0 to 5 cm in depth and obtained from residential properties or municipal parks. In addition to the 12 sites along each of the transects, two control sites were sampled from a list of preferred locations prepared by the AD HOC committee. The first control site was a residential property on Regency Square, about 3400 m W of the HCSTPI. The second control location for this survey was the lawn in front of Henry Hudson Public School, located about 4000 m NNW of the source. All soil samples in this part of the survey were analyzed for total Na, Sb, Se, Sr, V, Cu, Ni, Pb, Zn, Fe, Mn, Al, As, Cd, Co, Cr, Hg and Mo.

Results of Organic Analyses

PCBs were not detected in any of the soil samples collected during the re-survey of the three residential properties. The analytical detection limit was 0.02 ppm. Similarly, PCBs were not detected in any of the soil samples collected in the original HCSTPI soil survey conducted in November 1987.

Table 1 summarizes the PCDD and PCDF results from the 1987 survey Site 7, located on Colonel Danforth Trail. The soil at this site contained 430 ppt T_4CDD when it was first sampled. Dioxins from this congener group were not detected in the 1989 sampling, although other PCDD and PCDF congener groups were present. Discussions with the property owner revealed that wood ash had been composted in the yard and that the yard buildings and canoes constructed on-site had been treated with a pentachlorophenol-type wood preservative. These are both potential PCDD and PCDF sources. The highest total soil dioxin concentration (3080 ppt) was detected in the sample collected adjacent to the wood preservative-treated shed (Site 7-2, 1989). Dioxins and PCDFs were not detected in soil from the adjacent ravine (Site 7-4, 1989).

Table 2 summarizes the PCDD and PCDF results from the 1987 survey Site 8, located on Pepper Tree Drive. The soil at this site contained 93 ppt T_4CDD when it was first sampled. No T_4CDDs were detected in the 1989 re-sample, although H_7CDDs and O_8CDDs were encountered. Discussions with the property owner did not reveal any recent (last 5 years) land use practices which may have contributed to the presence of PCDDs or PCDFs. Replicate samples collected in 1989 from the same lawn area sampled in 1987 were comparable to each other (both contained 340 ppt total dioxins) but were considerably lower than the levels detected in the original sampling. Soil collected adjacent to old railway ties

used to frame a patio in the back yard contained 5100 ppt total PCDDs. The creosote-type wood preservatives formerly used on railway ties are potential PCDD sources. PCDDs and PCDFs were not detected in the soil from the adjacent playing field (Site 8-4, 1989).

Table 3 summarizes the PCDD and PCDF results from the 1987 survey Site 3, located on Satok Terrace. Soil at this site contained 310 ppt T_4CDD when sampling was conducted for the original HCSTPI survey. T_4CDD was not detected in soil from this property during the 1989 re-sample. The total PCDD levels were substantially lower and PCDFs were absent at this site in the second survey. PCDDs and PCDFs were not detected in soil from the ravine adjacent to the Satok Terrace property (Site 3-4, 1989).

PCDD and PCDF Toxic Equivalents

The Centre for Disease Control in Atlanta Georgia has developed a residential soil dioxin cleanup guideline. This guideline is 1 ppb and relates only to 2,3,7,8-T_4CDD. The US EPA uses this guideline as a bench mark in priortizing environmental Superfund remediation sites. The other PCDD and PCDF isomers and congener groups may be similar to or several thousand times less toxic than 2,3,7,8-T_4CDD. Although these other isomers/groups are less toxic, they are usually present in substantially higher concentrations. To address this concern the Canadian Council of Environment Ministers has proposed a guideline of 1 ppb 2,3,7,8-T_4CDD Toxic Equivalent (TEQ). The TEQ expresses the toxicity of each of the various congener groups relative to the most toxic 2,3,7,8-T_4CDD. The theoretical proportion of 2,3,7,8-substituted isomers in each of the congener groups and their relative TEQ factor may be revised periodically by the International Toxicity Factor Scheme as more PCDD and PCDF soil data become available.

Tables 4, 5 and 6 summarize the TEQ calculations for the PCDD and PCDF data from Sites 7, 8 and 3, respectively. The highest concentration detected on either sampling date for each congener group was used in these TEQ calculations. For example, the highest T_4CDD concentration at Site 7 (see Table 4) was 0.430 ppb. About 10% of the isomers in this congener group may be the most toxic 2,3,7,8-substitutions. Therefore, the estimated concentration of 2,3,7,8-substituted isomers in the T_4CDD congener group is 0.430 X 0.10 = 0.043 ppb. This is the only isomer group of concern in the T_4CDD conger group and so the TEQ factor of 1 is used. Therefore, the 2,3,7,8-T_4CDD TEQ of the T_4CDDs detected at Site 7 is 0.043 X 1 = 0.043 ppb. TEQs are calculated for each of the other congener groups in a similar fashion and the individual TEQs are summed for comparison to the proposed Canadian guideline of 1 ppb. Because this guideline was developed to protect human health it has a safety factor of 1000 or higher, i.e., the level has been set at least 1000 times lower

than the lowest concentration at which effects have been observed.

The TEQs for the three residential properties sampled in 1987 and again in 1989 are 0.08026, 0.05026 and 0.017935 ppb for Sites 7, 8 and 3, respectively. These TEQs, calculated from the maximum concentration detected for each congener group, are substantially below the proposed Canadian guideline.

Urban Background PCDD and PCDF Soil Data

The Phytotoxicology Section has an on-going PCDD/PCDF soil sampling program; therefore, the data base to which survey results such as the HCSTPI can be compared is constantly being up-dated. Table 7 summarizes soil PCDD and PCDF data for urban parks in Toronto, Hamilton and Welland. These sites were established to test for variability in PCDD and PCDF soil concentrations across a small defined area. Five replicate samples were collected from an area 20 m square in sites with no apparent signs of recent soil disturbance. The results of these analyses revealed that; 1) soil PCDD and PCDF concentrations can be measured in the thousands of ppt in urban areas removed from known or potential sources, and 2) variability is substantial even in small, well defined areas.

In light of the data from the recent soil variability survey, the variation in the PCDD and PCDF concentrations observed at the three HCSTPI residential sample sites does not appear unusual. The maximum concentrations of PCDDs and PCDFs detected in soil from residential properties for both the 1987 and 1989 surveys were well below the proposed Canadian guideline.

Results of Inorganic Analyses

The results of the inorganic analyses of the 12 sites collected from the NE and NW radii are summarized in Table 8. These data are also graphically illustrated in the figures appended to this report. The pattern of deposition from a stack source such as the HCSTPI is characteristically a second order polynomial. This means that deposition (and therefore soil accumulation) should be low close to the source, increase to a maximum at a distance from the source related to the nature of the emissions, and decrease beyond this point. Based on parameters such as stack height, stack gas temperature and velocity, topography, and wind patterns, the maximum ground level concentration of emissions from the HCSTPI stack was calculated to occur between 400 m and 861 m from the source. The tendency towards SW

winds during the time of the year when the ground is not snow covered would skew the area of maximum long term deposition in favour of the NE radius. Therefore, if the HCSTPI has had a measurable impact in regards to the soil, the appended concentration curves derived from the soil data in Table 8 should be low close to the source, reach a maximum between 500 and 1000 m, then decrease with increasing distance. Concentrations within the 500 to 1000 m distance along the NE radius should be noticeably higher than all other sampling sites. Arsenic is the only element which has a concentration curve that suggests stack emissions as a possible source; however, as this occurred only on the (upwind) NW radius and was not corroborated by similar levels at the corresponding location on the (downwind) NE radius, it would appear to be an anomalous finding. There is an industrial park to the NW of the HCSTPI where paint and metal alloy manufacturers are located. These sites are potential sources of the marginal As levels found to the NW of the sewage incinerator.

Non-stack Related Soil Contamination

When the chemical analyses were received from the MOE laboratory it was observed that most of the values for site NE 500 were considerably elevated relative to the other sample sites. Unlike all other survey sites, a few elements (Cu, Cd and Cr) at NE 500 exceeded the Phytotoxicology urban ULN guidelines (Table 9). Both NE 250 and NE 500 were located on the HCSTPI property. NE 500 was situated in a sodded area near the Chlorine Contact Chamber. The presence of established landscape trees suggested that this area had not been recently disturbed. Discussions with the HCSTPI staff confirmed that the area had not been disturbed and that incinerator ash, a potential source of contamination, had not been disposed of in the vicinity of the Chlorine Contact Chamber. The soil around NE 500 was re-sampled on October 19 1989, after confirming with the laboratory that the original analytical data for this site were valid. Triplicate samples were collected from four additional sites in the vicinity of NE 500. These samples were processed and analyzed on a priority basis so that the release of this report would not be unnecessarily delayed.

Table 9 summarizes the results of the additional sampling. Data in this table include the soil concentrations for the original NE 500 sample collected in May 1989, a re-sample of the same site, soil collected from an area adjacent to the original sample in the vicinity of the Chlorine Contact Chamber, a site on top of an earth berm about 30 m from the original site, and a sample of a mixture of incinerator ash and soil from the on-site ash disposal area. The results for the Original, Re-sample, and Adjacent sites are very consistent, thereby confirming the first set of results for NE 500. The levels encountered in this area are much too high to be associated with atmospheric deposition. Proportionately elevated soil concentrations should have occurred elsewhere along the NE radius and at the same

distance on the NW radius. These elevations did not occur, suggesting a contamination source specific to the sample area around NE 500. Also, the Hill Top sample site was the same relative distance from the HCSTPI stack and, being higher and directly exposed, would more likely be impacted by stack emissions than the surrounding lower ground. The concentrations of most elements were much lower at the Hill Top sample site; in fact they were comparable to the levels detected at most other sites along the two sampling radii. The sample of the soil/incinerator ash mixture was significantly contaminated with heavy metals.

On the basis of these findings, the source of the contamination at the original NE 500 sampling site was probably fugitive emissions blowing from the incinerator ash pile, or possibly ash contaminated soil washing from the roadway into the sodded area in the vicinity of the Chlorine Contact Chamber. The Hill Top sample site would be less likely affected by ground level fugitive emissions and would, therefore, be a better site to use in the survey to assess the potential impact of atmospheric deposition. Ground level fugitive emissions associated with the movement or inventory of incinerator ash would be very localized.

Statistical Tests for Stack-Related Soil Contamination

Table 10 summarizes the soil concentrations detected at the two control sites selected by the Ad HOC committee. These data are compared with the corresponding mean values for the original control site used in the first MOE HCSTPI soil survey. The selection of the original control site was criticized as not being representative of the survey area. It was also alleged that this control site biased the interpretation of the survey results. The data in Table 10 reveal that relative to the control sites chosen by the AD HOC committee, 2 of the 14 elements were marginally lower (compared to the range in 1989) in soil from the original control site, 3 were marginally higher, and there was essentially no difference between the control sites for the remaining 9 elements. This confirms that, in regards to soil chemistry, the original control site was an acceptable location and did not result in any bias in the interpretation of the 1987 survey results.

Although the deposition graphs for each element do not indicate a relationship with distance from the HCSTPI, the data were analyzed statistically to determine if trends were present which were not apparent through simple visual inspection of the appended figures. It is logical to assume that because of the prevailing wind patterns in the vicinity of the HCSTPI that deposition, and therefore soil accumulation, would be somewhat higher along the NE radius. To test this assumtion the mean concentration of each element was calculated for the NE and NW radii and compared with each other and with the mean values from the

(AD HOC) control sites. A "t" test was used to determine if absolute differences were statistically significant.

The data are summarized in Table 11. Of the 18 elements, only Ni, Co and Cr were found to be significantly higher along the NE radius compared to the NW radius, whereas As was significantly lower from the NE relative to the NW. In relation to the control sites, Sb and Pb levels were significantly lower from the NE radius and As, Co and Cr levels were significantly higher. The soil Sb and Sr concentrations from the NW radius were significantly lower than the control sites, whereas the As levels from the NW were significantly higher. Therefore, of all the elements, only Co and Cr were detected in higher concentrations along the NE radius relative to both the NW radius and the control sites.

The higher Cr and Co concentrations, although statistically significant, are environmentally inconsequential, both being well within the normal range for Ontario soil. Although the absolute differences were very marginal it was considered possible that they were source related. In order to explore this possibility, the data were statistically examined relative to the distances predicted by the stack deposition models. These models predicted that maximum ground level concentrations (C Max) would occur between 400 and 861 m from the stack. The mean soil concentrations were calculated for the three sample sites on both radii which bracketed the predicted C Max (500 m, 750 m and 1000 m sites). Similarly, the mean soil levels were calculated for the three most distant sites (2500 m, 2750 m and 3000 m sample points). A "t" test was used to identify significant differences in soil concentrations between the predicted maximum and minimum areas of deposition and the control sites.

These data are summarized in Table 12. There were no statistically significant differences between the soil concentrations detected from the area of predicted maximum deposition and the sites farthest from the HCSTPI. The levels of Na, Se and Cu were significantly higher from the C Max zone compared to the control sites, but yet there was no significant difference in the concentrations of these elements between the downwind (NE) and the upwind (NW) radii. Similarly, As and Mo were detected in significantly higher concentrations from the minimum deposition zone (farthest sites) relative to the control sites. Therefore, based on this analysis, there was no indication that the elevated Cr and Co concentrations detected on the NE radius were due to atmospheric deposition in the C Max zone.

Even though a few of the elemental soil concentrations were higher than the control sites they are not related to emissions from the HCSTPI; rather, they represent the natural variability of inorganic soil chemistry inherent in an urban environment.

Conclusions

The 1989 supplementary soil survey re-affirmed the results and conclusions of the original survey conducted around the HCSTPI in 1987. Both the organic and inorganic soil chemistry was indicative of urban residential or parkland property in Ontario from areas remote from the direct influence of industrial emissions. There was no detectable relationship between soil chemistry and distance or direction from the HCSTPI.

This survey did, however, identify a potential source of localized contamination. The incinerator ash is contaminated with heavy metals. Ash inventoried on HCSTPI property may contaminate soil through fugitive emissions (ash blowing from the pile, or ash movement through surface water run-off and re-distribution by vehicle traffic). Contamination of this nature would be restricted to the immediate vicinity of the ash pile and directly adjacent to the roadways used to access the storage and handling areas. Although this may be a concern on HCSTPI property near the ash storage and handling areas, there was no evidence in either 1987 or 1989 that off property contamination has occurred.

Table 1
PCDD and PCDF Concentrations in Soil at (1987)
HCSTPI Survey Site 7
(Colonel Danforth Trail - 1,360 m NNW)

	Concentration (ppt)				
PCDD	1987	1989			
		Site 7-1	Site 7-2	Site 7-3	Site 7-4
2,3,7,8-T_4CDD	NA	ND	ND	ND	ND
T_4CDD	430	ND	ND	ND	ND
P_5CDD	540	ND	ND	ND	ND
H_6CDD	ND	ND	ND	ND	ND
H_7CDD	300	180	480	ND	ND
O_8CDD	1500	1100	2600	690	ND
Total PCDD	2770	1280	3080	690	ND
PCDF					
T_4CDF	ND	ND	ND	ND	ND
P_5CDF	ND	ND	ND	ND	ND
H_6CDF	ND	ND	80	ND	ND
H_7CDF	ND	ND	110	ND	ND
O_8CDF	180	190	210	ND	ND
Total PCDF	180	190	400	ND	ND

NA - not analyzed
ND - not detected, less than the analytical detection limits
Site 7-1 - back yard near wood ash/compost pile.
Site 7-2 - back yard near wood preservative treated shed.
Site 7-3 - back yard flower garden.
Site 7-4 - mid-slope of ravine behind property.

Table 2
PCDD and PCDF Cncentrations in Soil at the (1987)
HCSTPI Survey Site 8
(Pepper Tree Dr. - 1,430 m NE)

	Concentration (ppt)				
PCDD	1987	1989			
		Site 8-1	Site 8-2	Site 8-3	Site 8-4
2,3,7,8-T_4CDD	NA	ND	ND	ND	ND
T_4CDD	93	ND	ND	ND	ND
P_5CDD	56	ND	ND	ND	ND
H_6CDD	40	ND	ND	ND	ND
H_7CDD	210	60	ND	1500	ND
O_8CDD	1300	280	340	3600	ND
Total PCDD	1699	340	340	5100	ND
PCDF					
T_4CDF	ND	ND	ND	ND	ND
P_5CDF	ND	ND	ND	ND	ND
H_6CDF	ND	ND	ND	ND	ND
H_7CDF	ND	ND	ND	ND	ND
O_8CDF	ND	35	ND	ND	ND
Total PCDF	ND	35	ND	ND	ND

NA - not analyzed.
ND - not detected, less than the analytical detection limits.
Site 8-1 - front yard, replicate 1.
Site 8-2 - front yard, replicate 2.
Site 8-3 - back yard next to rail road ties.
Site 8-4 - playing field south of Lawrence Ave., opposite Sir Oliver Mowat Collegiate Institute.

Table 3
PCDD and PCDF Concentrations in Soil at the (1987)
HCSTPI Survey Site 3
(Satok Ter. - 810 m NNW)

	Concentration (ppt)				
PCDD	1987	1989			
		Site 3-1	Site 3-2	Site 3-3	Site 3-4
2,3,7,8-T_4CDD	NA	ND	ND	ND	ND
T_4CDD	310	ND	ND	ND	ND
P_5CDD	370	ND	ND	ND	ND
H_6CDD	ND	ND	ND	ND	ND
H_7CDD	ND	ND	ND	30	ND
O_8CDD	380	ND	110	130	ND
Total PCDD	1060	ND	110	160	ND
PCDF					
T_4CDF	ND	ND	ND	ND	ND
P_5CDF	ND	ND	ND	ND	ND
H_6CDF	ND	ND	ND	ND	ND
H_7CDF	ND	ND	ND	ND	ND
O_8CDF	230	ND	ND	ND	ND
Total PCDF	230	ND	ND	ND	ND

NA - not analyzed.
ND - not detected, less than the analytical detection limits.
Site 3-1 - front yard, replicate 1.
Site 3-2 - front yard, replicate 2.
Site 3-3 - back yard.
Site 3-4 - mid-slope of ravine behind property.

Table 4
Toxic Equivalent Calculations for the Maximum PCDD and PCDF Concentrations in Soil at (1987) HCSTPI Survey Site 7

Isomer Group	Maximum Soil Concentration ppb	Theoretical Proportion of 2,3,7,8-substituted Isomers*	Estimated Concentration of 2,3,7,8-isomers ppb	Toxic Equivalent Factor*	2,3,7,8-T_4CDD Toxic Equivalent ppb
T_4CDD	0.430	10%	0.043	1	0.043
P_5CDD	0.540	10%	0.054	0.5	0.027
H_6CDD	ND	30%	ND	0.1	ND
H_7CDD	0.480	60%	0.288	0.01	0.0029
O_8CDD	2.600	100%	2.600	0.001	0.0026
T_4CDF	ND	10%	ND	0.1	ND
P_5CDF	ND	15%	ND	0.5	ND
H_6CDF	0.080	50%	0.040	0.1	0.004
H_7CDF	0.110	50%	0.055	0.01	0.00055
O_8CDF	0.210	100%	0.210	0.001	0.00021
Total 2,3,7,8-T_4CDD Toxic Equivalents - ppb					0.08026
Proposed Canadian Guideline - ppb					1.0

* As Recently Revised by the International Toxicity Factor Scheme
ND - not detected

Table 5
Toxic Equivalent Calculations for the Maximum PCDD and PCDF Concentrations in Soil at the (1987) HCSTPI Survey Site 8

Isomer Group	Maximum Soil Concentration ppb	Theoretical Proportion of 2,3,7,8-substituted Isomers*	Estimated Concentration of 2,3,7,8-isomers ppb	Toxic Equivalent Factor*	2,3,7,8-T4CDD Toxic Equivalent ppb
T_4CDD	0.093	10%	0.0093	1	0.0093
P_5CDD	0.056	10%	0.0056	0.5	0.0028
H_6CDD	0.040	30%	0.0120	0.1	0.0012
H_7CDD	1.500	60%	0.9000	0.01	0.0010
O_8CDD	3.600	100%	3.6000	0.001	0.0036
T_4CDF	ND	10%	ND	0.1	ND
P_5CDF	ND	15%	ND	0.5	ND
H_6CDF	ND	50%	ND	0.1	ND
H_7CDF	ND	50%	ND	0.01	ND
O_8CDF	0.035	100%	0.0350	0.001	0.000035
		Total 2,3,7,8-T_4CDD Toxic Equivalents - ppb			0.017935
		Proposed Canadian Guideline - ppb			1.0

* As Recently Revised by the International Toxicity Factor Scheme
ND - not detected

Table 6
Toxic Equivalent Calculations for the Maximum PCDD and PCDF Concentrations in Soil at the (1987) HCSTPI Survey Site 3

Isomer Group	Maximum Soil Concentration ppb	Theoretical Proportion of 2,3,7,8-substituted Isomers*	Estimated Concentration of 2,3,7,8-isomers ppb	Toxic Equivalent Factor*	2,3,7,8-T4CDD Toxic Equivalent ppb
T_4CDD	0.310	10%	0.031	1	0.031
P_5CDD	0.370	10%	0.037	0.5	0.0185
H_6CDD	ND	30%	ND	0.1	ND
H_7CDD	0.030	60%	0.018	0.01	0.00018
O_8CDD	0.380	100%	0.380	0.001	0.00038
T_4CDF	ND	10%	ND	0.1	ND
P_5CDF	ND	15%	ND	0.5	ND
H_6CDF	ND	50%	ND	0.1	ND
H_7CDF	ND	50%	ND	0.01	ND
O_8CDF	0.230	100%	0.230	0.001	0.0002
		Total 2,3,7,8-T_4CDD Toxic Equivalents - ppb			0.05026
		Proposed Canadian Guideline - ppb			1.0

* As Recently Revised by the International Toxicity Factor Scheme
ND - not detected

Table 7
Concentrations of PCDDs and PCDFs in Soil
at Three Urban Park Variability Study Sites

Isomer Group	Toronto Mean	Toronto Range	Hamilton Mean	Hamilton Range	Welland Mean	Welland Range
T_4CDD	403	ND - 1200	ND	-	ND	-
P_5CDD	67	ND - 130	ND	-	ND	-
H_6CDD	ND	-	ND	-	ND	-
H_7CDD	41	ND - 140	52	ND - 170	361	ND - 1100
O_8CDD	466	140 - 1200	5520	1100 - 16,000	4222	ND - 10,000
T_4CDF	ND	-	3	ND - 14	7	ND - 35
P_5CDF	ND	-	ND	-	202	ND - 660
H_6CDF	ND	-	ND	-	38	ND - 120
H_7CDF	ND	-	ND	-	148	ND - 410
O_8CDF	40	ND - 81	ND	-	190	ND - 600

Data are ppt, mean of 5 replicates, sampled in 1988 from urban parks
ND - not detected
- no range to report

Table 8
Concentration of Inorganic Elements in Soil along a NE and NW Transect
from the Highland Creek Sewage Treatment Plant Incinerator
May 1989

	Concentration (ppm)																
m NE	Na	Sb	Se	Sr	V	Cu	Nl	Pb	Zn	Fe	Mn	Al	As	Cd	Co	Cr	Hg	Mo
250	220	<.2	.3	56	34	63	14	33	90	1.8	370	1.1	1.7	1.4	7.3	37	.18	.8
500	207	<.2	.3	63	33	37	18	13	47	1.6	354	1.2	1.6	.42	10.0	36	.02	.3
750	220	<.2	.2	57	31	17	12	27	50	1.5	360	1.1	2.0	.27	7.2	21	<.02	.4
1000	250	<.2	.2	66	36	22	13	33	50	1.7	390	1.2	2.0	<.20	8.3	25	<.02	.5
1250	430	.5	.3	100	27	26	10	98	68	1.4	280	0.8	2.2	.70	6.2	37	<.02	.5
1500	210	.3	<.2	45	29	12	9	18	41	1.3	260	1.0	2.0	.31	6.1	29	<.02	.5
1750	245	<.2	.2	87	28	14	9	22	35	1.3	310	0.9	2.5	.25	6.0	18	<.02	.6
2000	170	.2	.3	54	34	20	13	30	50	1.6	360	1.2	3.3	.33	7.9	23	<.02	.4
2250	180	<.2	.3	38	37	22	14	33	59	1.7	410	1.4	2.8	.38	8.6	24	<.02	.7
2500	105	<.2	.3	20	24	8	5	35	31	1.1	160	0.7	2.9	.28	4.6	14	<.02	.4
2750	200	<.2	.3	29	43	20	15	24	50	2.0	440	1.6	3.5	.27	10.0	26	<.02	.5
3000	270	<.2	<.2	110	24	17	8	40	40	1.1	250	0.6	1.5	.31	4.8	16	<.02	.3
Mean	226	<.2	.2	60	32	23	12	34	51	1.5	329	1.1	2.3	.42	7.3	26	.03	.5
ULN	NA	8	2	NA	70	100	60	500	500	3.5	700	NA	20	4	25	50	.50	3
m NW																		
250	240	.2	.4	32	36	24	11	30	80	1.7	275	1.3	2.9	.59	7.3	21	.02	.4
500	210	<.2	.3	32	31	21	10	34	51	1.4	200	1.0	2.5	.31	5.5	18	<.02	.4
750	250	.3	.3	65	27	28	8	74	86	1.4	230	.8	6.4	.49	4.9	22	.03	.8
1000	220	.3	.3	54	26	24	7	66	72	1.3	197	.7	3.8	.38	4.2	20	<.02	.3
1250	170	<.2	.2	38	27	14	8	23	43	1.3	283	.9	2.8	.22	5.1	15	<.02	.3
1500	200	<.2	<.2	63	25	14	9	50	48	1.2	243	.7	2.1	.35	4.4	20	<.02	.3
1750	150	<.2	<.2	34	26	10	6	25	36	1.3	190	.6	1.8	.21	3.9	13	<.02	.5
2000	160	<.2	.3	28	22	10	6	41	40	1.1	210	.7	2.6	.23	4.1	14	<.02	.3
2250	240	<.2	.2	44	29	17	8	53	51	1.4	310	1.0	3.0	.36	5.2	20	<.02	.3
2500	180	<.2	.7	56	37	33	13	28	58	1.7	370	1.2	3.7	.39	7.6	22	.13	1.0
2750	120	.4	.3	33	29	19	7	300	100	1.4	250	.7	2.8	.50	5.3	15	.23	.5
3000	160	.3	.3	41	35	22	11	44	66	1.6	330	1.2	2.7	.45	7.2	20	<.02	.6
Mean	192	<.2	.3	43	29	20	9	64	61	1.4	257	.9	3.1	.38	5.4	18	.04	.5
ULN	NA	8	2	NA	70	100	60	500	500	3.5	700	NA	20	4	25	50	.50	3

Data are mean of triplicate samples, ppm dry weight, except Fe and Al, which are percent.
ULN - Phytotoxicology Upper Limit of Normal Guideline.
NA - ULN not available.
Radii Mean - data less than detection limit assumed to be 1/2 detection limit for mean calculation.
Data for NE 500 are from Hill Top Site of October sampling.

Table 9
Comparison of Soil Chemistry at Sample Site NE 500

	Concentration - ppm				
Element	Original	Re-sample	Adjacent	Hill Top	Soil/Ash
V	32	29	31	33	530
Mo	1.2	0.7	0.4	0.3	14
Sr	71	53	47	63	229
Hg	0.36	0.50	0.47	0.02	0.69
Cu	340	173	96	37	3020
Ni	29	22	17	18	101
Zn	440	359	153	47	2240
Cd	7.0	4.9	2.5	0.42	131
Co	8.3	8.6	9.0	10.0	15.7
Cr	200	103	4.6	36	873
Pb	130	71	36	13	604
Fe %	2.0	1.6	1.5	1.6	10.5
Mn	340	377	347	354	1120
Al %	1.4	1.2	1.2	1.2	1.1
Na	270	150	163	207	1110
As	2.5	2.5	2.5	1.6	11
Se	0.30	0.68	0.60	0.30	2.00
Sb	3.3	3.0	1.2	<0.2	3.1

Original - NE 500 originally sampled May 1989.
Re-sample - NE 500 re-sampled October 1989.
Adjacent - site adjacent to NE 500 sampled October 1989.
Hill Top - site on top of burm, same relative distance from HCSTP as NE 500, sampled October 1989.
Soil/Ash - mixture of soil and HCSTP incinerator ash stock piled close to NE 500, sampled October 1989.
Underlined values exceed urban ULN.

Table 10
Statistical Description of the Soil Chemistry for the Two 1989 Control Sites Relative to the 1987 Survey Control

Element	Concentration (ppm) 1989 Mean	Standard Deviation	Range	1987 (Original) Mean
Cu	17	2	15 - 19	12
Ni	10	2	8 - 12	7
Pb	54	9	44 - 62	74
Zn	58	4	51 - 62	62
Fe	1.4	0.2	1.1 - 1.6	1.3
Mn	313	66	250 - 380	NA
Al	0.9	0.3	0.6 - 1.1	NA
As	1.7	0.3	1.3 - 2.0	2.2
Cd	0.32	0.06	0.22 - 0.41	0.30
Co	5.5	1.0	4.4 - 6.6	NA
Cr	19	4	15 - 23	19
Hg	0.02	0.004	<0.02 - 0.03	0.02
Mo	0.4	0.1	<0.3 - 0.5	<1
Na	192	10	180 - 200	185
Sb	0.49	0.34	<0.20 - 1.0	<0.30
Se	0.21	0.02	<0.20 - 0.23	0.50
Sr	61	19	40 - 83	NA
V	28	4	23 - 32	27

* Data are ppm dry weight, mean of 6 replicates (1989) and 2 replicates (1987)
NA - not analyzed
Original Control was Site 13 in March 1989 HCSTP Soil Survey Report, sampled November, 1987.

Table 11

Comparison Between the Inorganic Soil Chemistry
of the NE and NW Radii Means and the Control Sites

Element	Mean Concentration - ppm			Statistical Sig. p<		
	NE Radius	NW Radius	Control	NE/NW	NE/Con	NW/Con
Na	226	192	192	NS	NS	NS
Sb	<0.2	<0.2	0.5	NS	.01	.01
Se	0.2	0.3	0.2	NS	NS	NS
Sr	60	43	61	NS	NS	.05
V	32	29	28	NS	NS	NS
Cu	23	20	17	NS	NS	NS
Ni	12	9	10	.05	NS	NS
Pb	34	64	54	NS	.05	NS
Zn	51	61	58	NS	NS	NS
Fe %	1.5	1.4	1.4	NS	NS	NS
Mn	329	257	313	NS	NS	NS
Al %	1.1	0.9	0.9	NS	NS	NS
As	2.3	3.1	1.7	.05	.05	.01
Cd	0.42	0.38	0.32	NS	NS	NS
Co	7.3	5.4	5.5	.01	.05	NS
Cr	26	18	19	.01	.05	NS
Hg	0.03	0.04	0.02	NS	NS	NS
Mo	0.5	0.5	0.4	NS	NS	NS

NS - not significant, P>0.05
NE/NW - NE Radius vs NW Radius
NE/Con - NE Radius vs Control
NW/Con - NW Radius vs Control

Table 12

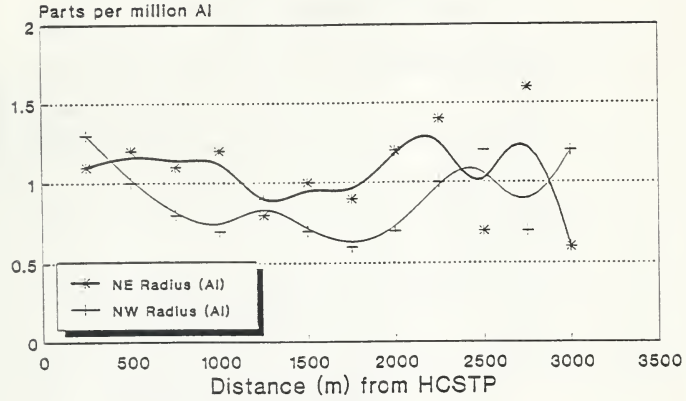
Comparison Between the Soil Inorganic Chemistry of Sample Sites Close to the C Max, Farthest from the Source and the Control Sites

Element	Concentration - ppm			Statistical Sig. p<		
	C Max	Farthest	Control	CMX/Far	CMX/Con	Far/Con
Na	226	173	192	NS	.01	NS
Sb	<0.2	<0.2	0.5	NS	NS	NS
Se	0.3	0.3	0.2	NS	.01	NS
Sr	45	48	61	NS	NS	NS
V	31	32	28	NS	NS	NS
Cu	25	20	17	NS	.05	NS
Ni	11	10	10	NS	NS	NS
Pb	41	79	54	NS	NS	NS
Zn	59	58	58	NS	NS	NS
Fe	1.5	1.5	1.4	NS	NS	NS
Mn	289	300	313	NS	NS	NS
Al	1.0	1.0	0.9	NS	NS	NS
As	3.1	2.9	1.7	NS	NS	.01
Cd	0.33	0.37	0.32	NS	NS	NS
Co	6.7	6.6	5.5	NS	NS	NS
Cr	24	19	19	NS	NS	NS
Hg	0.02	0.07	0.02	NS	NS	NS
Mo	0.5	0.6	0.4	NS	NS	.05

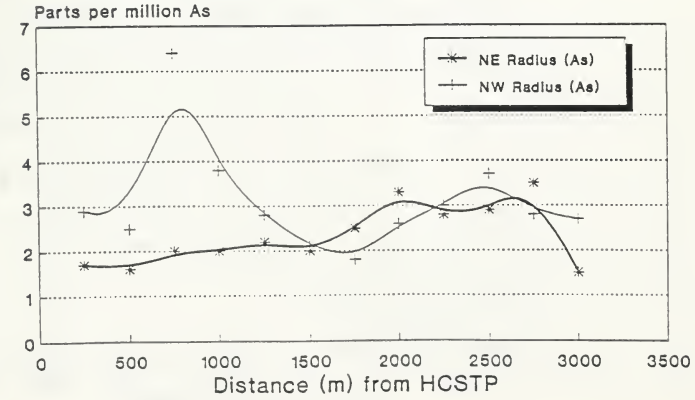
NS - not significant, P>0.05
C Max - mean of Sites 500, 750 and 1000 NE and NW Radii.
Farthest - mean of Sites 2500, 2750 and 3000 NE and NW Radii.
CMX/Far - C Max sites vs sites Farthest from the source.
CMX/Con - C Max sites vs Control sites.
Far/Con - Sites Farthest from Source vs Control sites.

Concentration Curves for Inorganic Elements in Soil

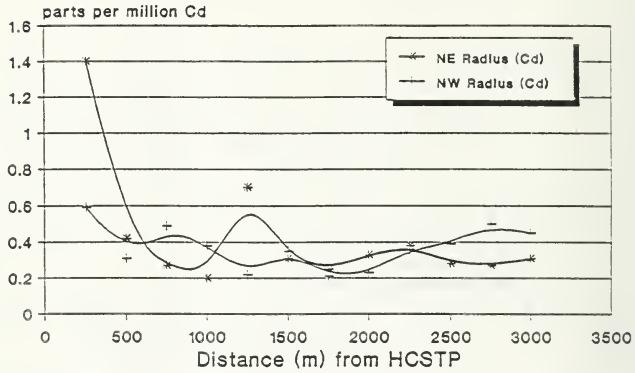
HCSTP Soil Survey
Al in Surface Soil (0 - 5 cm)



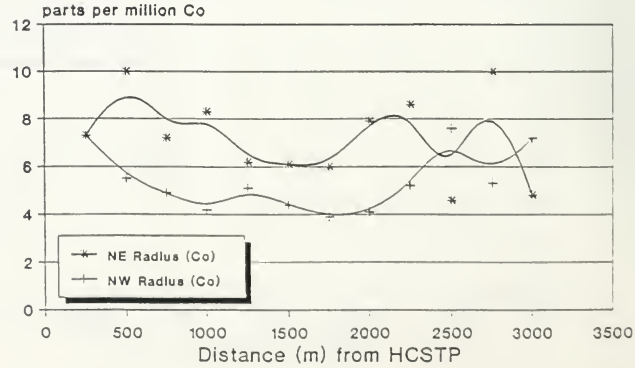
HCSTP Soil Survey
As in Surface Soil (0 - 5 cm)



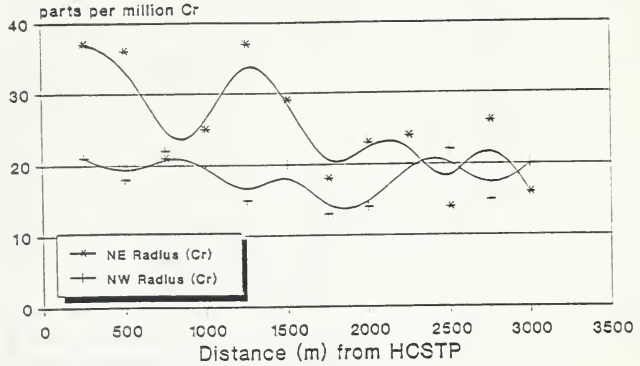
HCSTP Soil Survey
Cd in Surface Soil (0 - 5 cm)



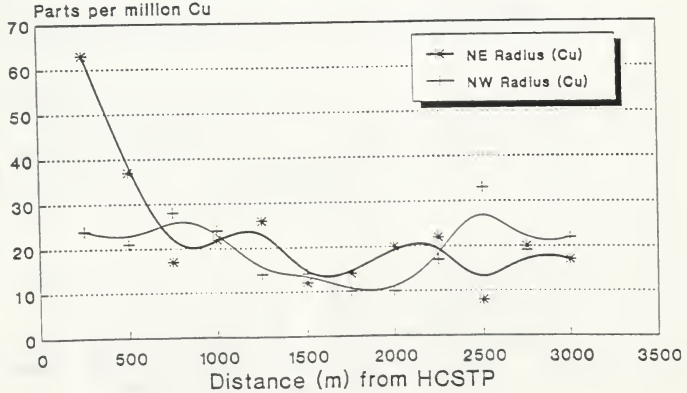
HCSTP Soil Survey
Co in Surface Soil (0 - 5 cm)



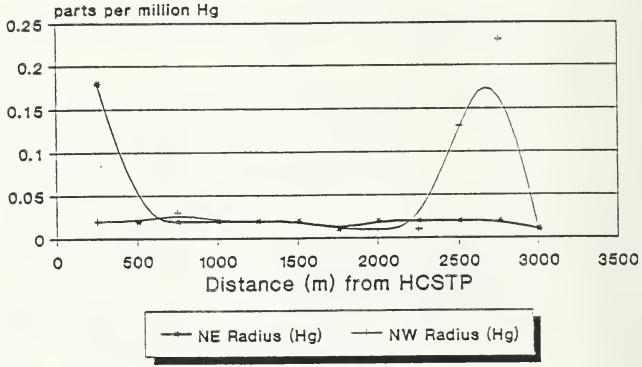
HCSTP Soil Survey
Cr in Surface Soil (0 - 5 cm)



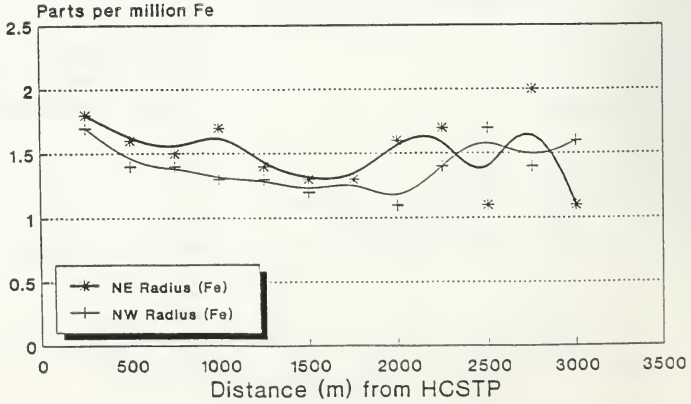
HCSTP Soil Survey
Cu in Surface Soil (0 - 5 cm)



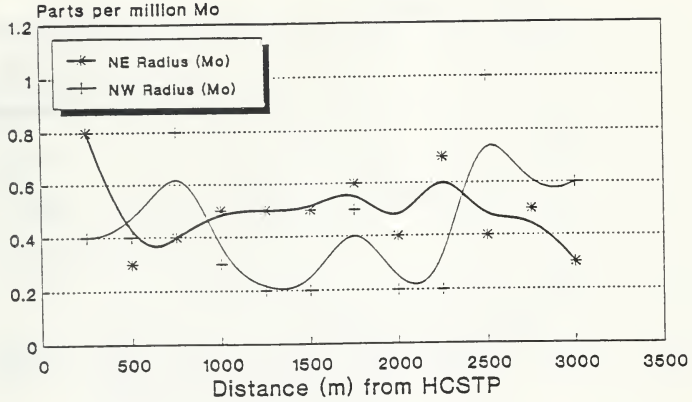
HCSTP Soil Survey
Hg in Surface Soil (0 - 5 cm)



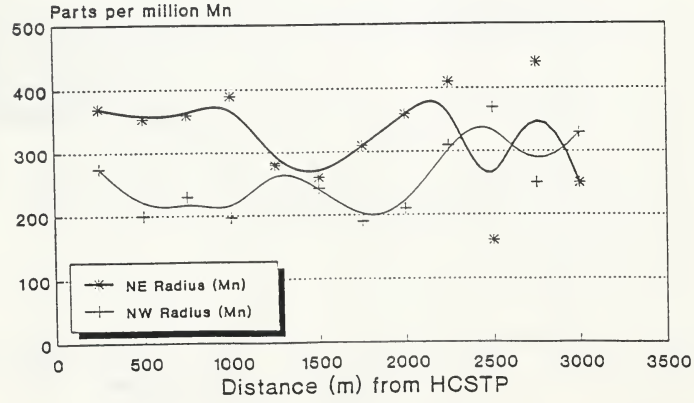
HCSTP Soil Survey
Fe in Surface Soil (0 - 5 cm)



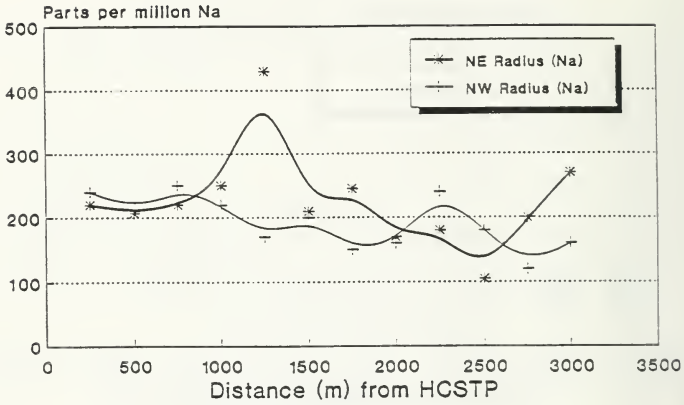
HCSTP Soil Survey
Mo in Surface Soil (0 - 5 cm)



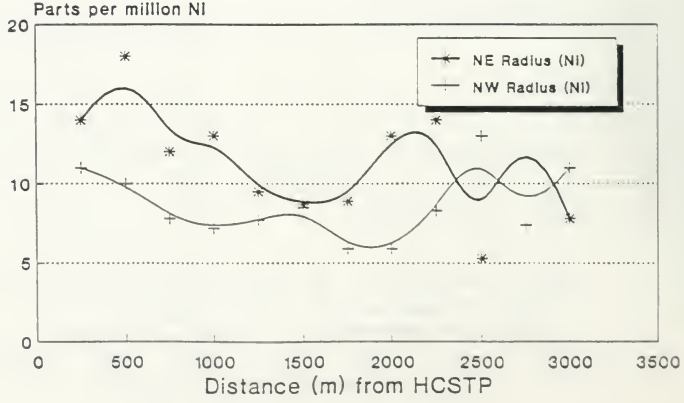
HCSTP Soil Survey
Mn in Surface Soil (0 - 5 cm)



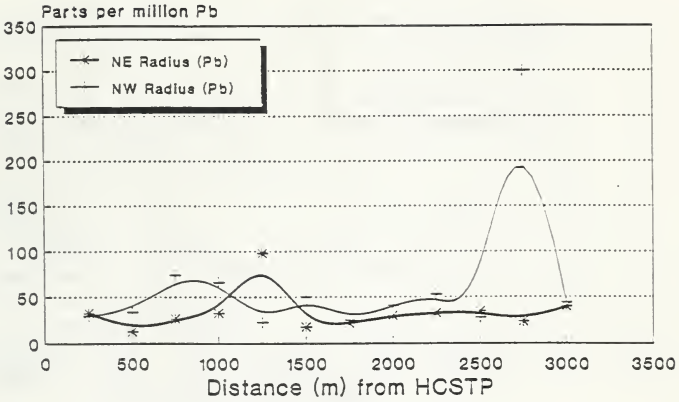
HCSTP Soil Survey
Na in Surface Soil (0 - 5 cm)



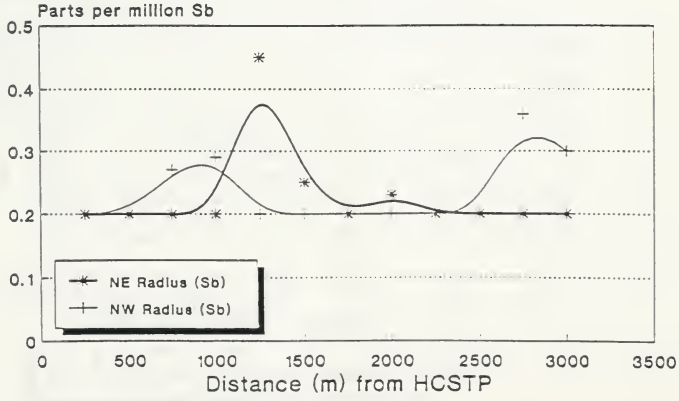
HCSTP Soil Survey
Ni in Surface Soil (0 - 5 cm)



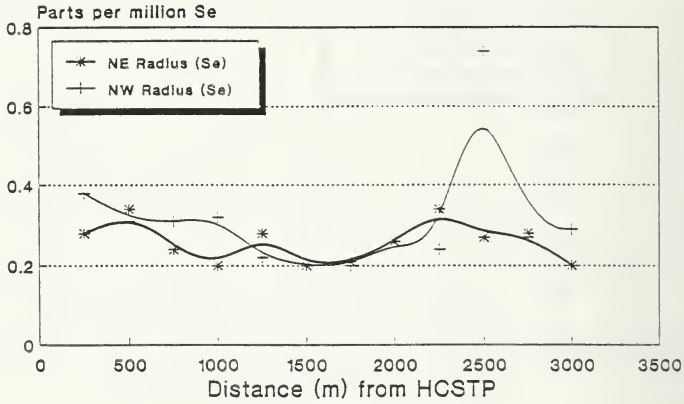
HCSTP Soil Survey
Pb in Surface Soil (0 - 5 cm)



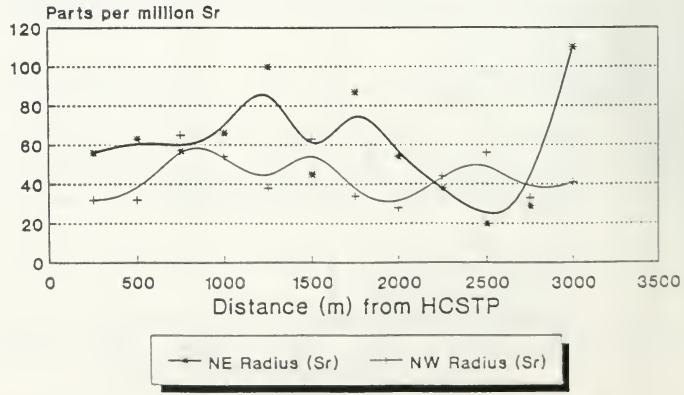
HCSTP Soil Survey
Sb in Surface Soil (0 - 5 cm)



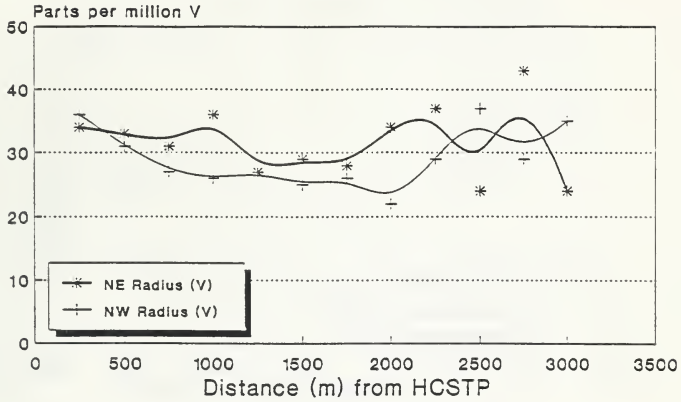
HCSTP Soil Survey
Se in Surface Soil (0 - 5 cm)



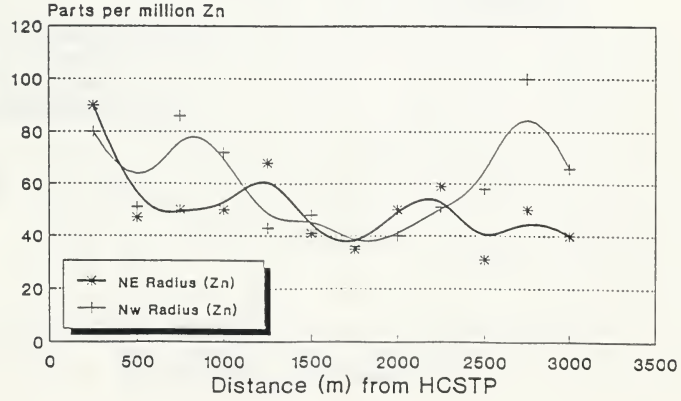
HCSTP Soil Survey
Sr in Surface Soil (0 - 5 cm)



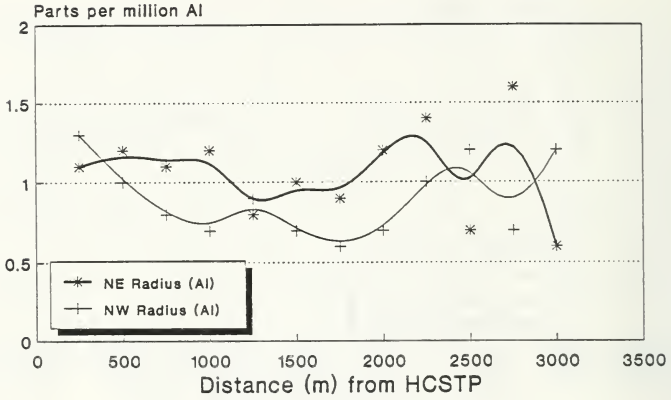
HCSTP Soil Survey
V in Surface Soil (0 - 5 cm)



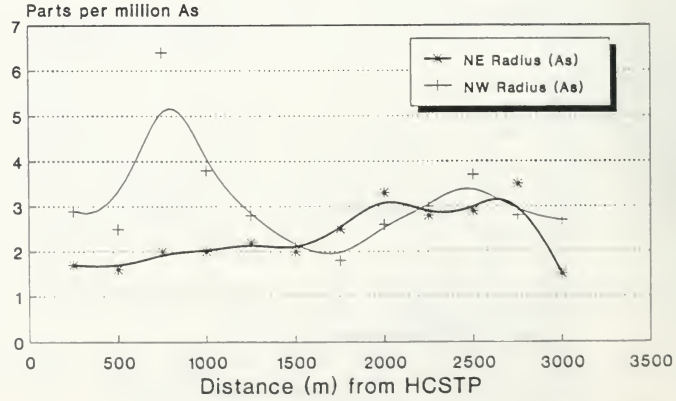
HCSTP Soil Survey
Zn in Surface Soil (0 - 5 cm)



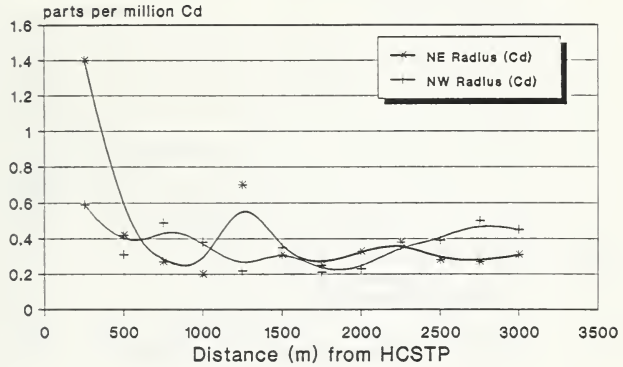
HCSTP Soil Survey
Al in Surface Soil (0 - 5 cm)



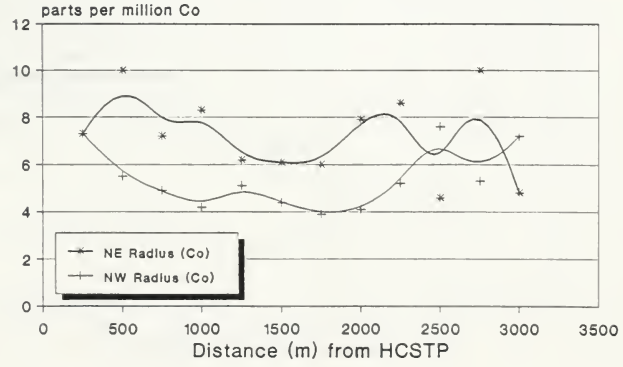
HCSTP Soil Survey
As in Surface Soil (0 - 5 cm)



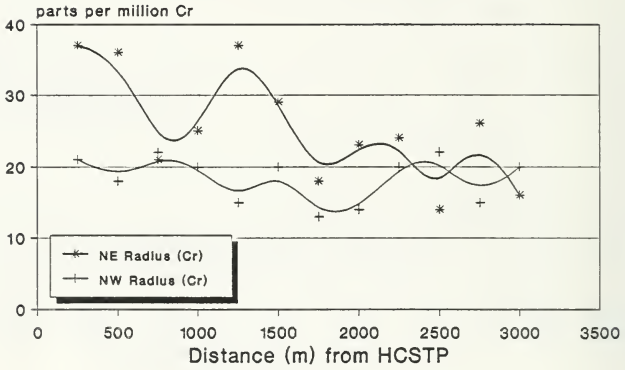
HCSTP Soil Survey
Cd in Surface Soil (0 - 5 cm)



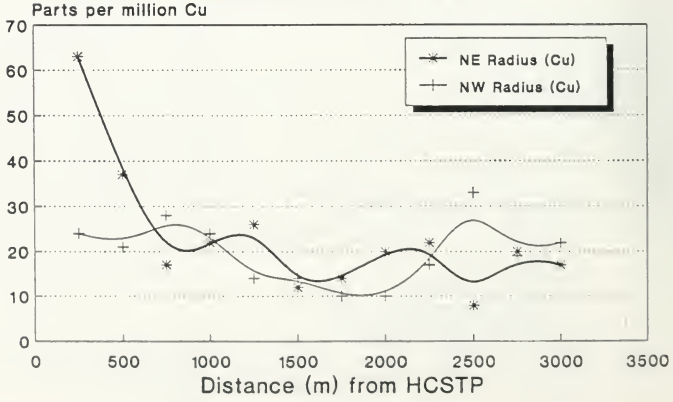
HCSTP Soil Survey
Co in Surface Soil (0 - 5 cm)



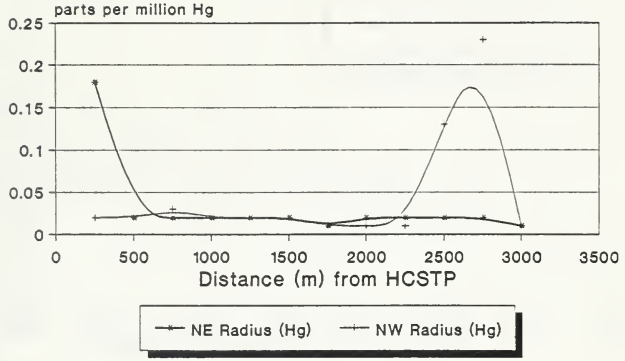
HCSTP Soil Survey
Cr in Surface Soil (0 - 5 cm)



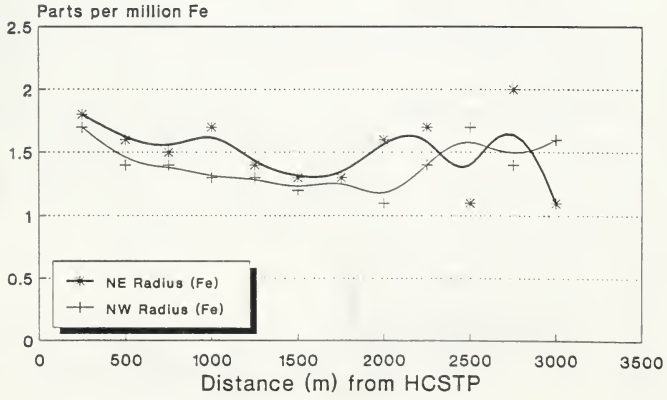
HCSTP Soil Survey
Cu in Surface Soil (0 - 5 cm)



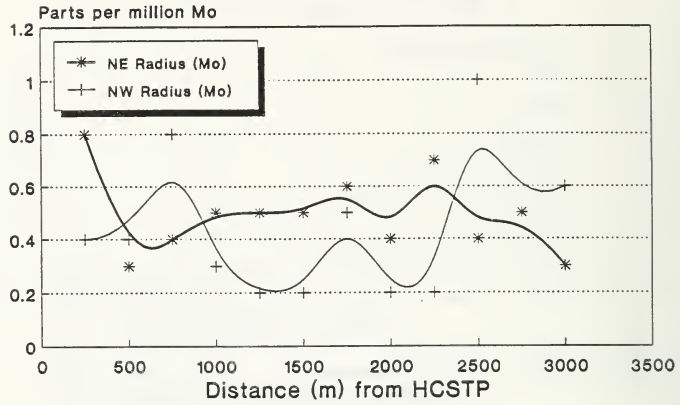
HCSTP Soil Survey
Hg in Surface Soil (0 - 5 cm)



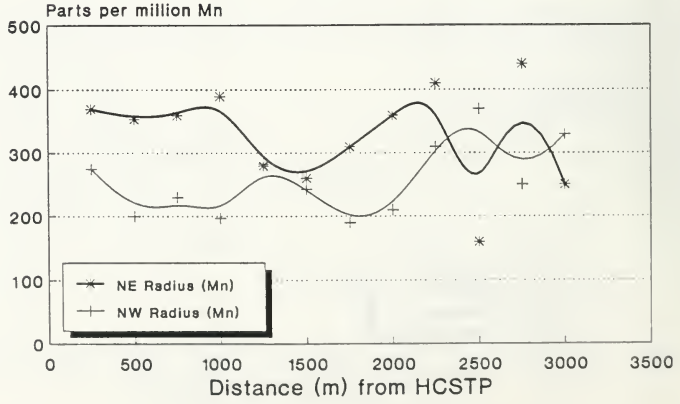
HCSTP Soil Survey
Fe in Surface Soil (0 - 5 cm)



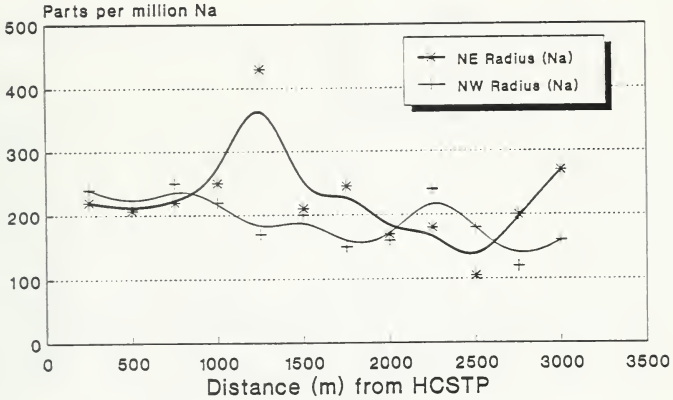
HCSTP Soil Survey
Mo in Surface Soil (0 - 5 cm)



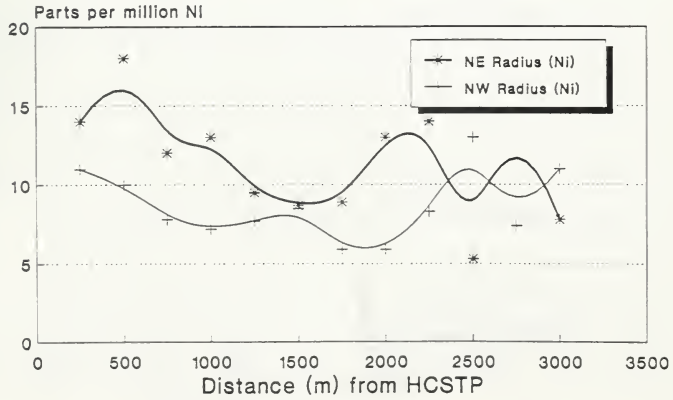
HCSTP Soil Survey
Mn in Surface Soil (0 - 5 cm)



HCSTP Soil Survey
Na in Surface Soil (0 - 5 cm)



HCSTP Soil Survey
Ni in Surface Soil (0 - 5 cm)



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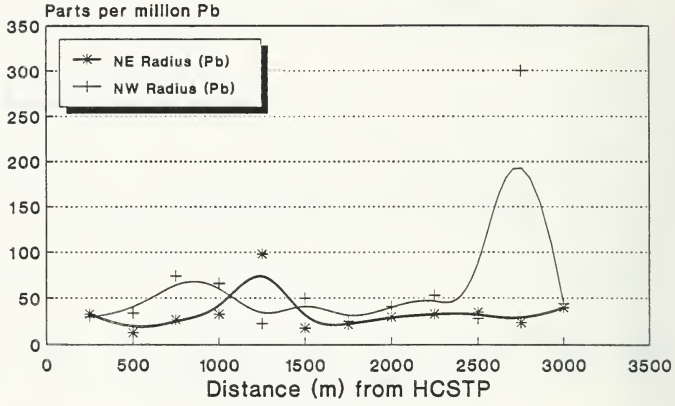
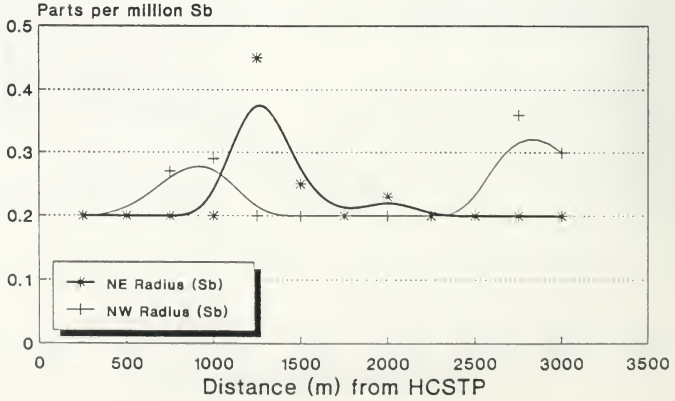
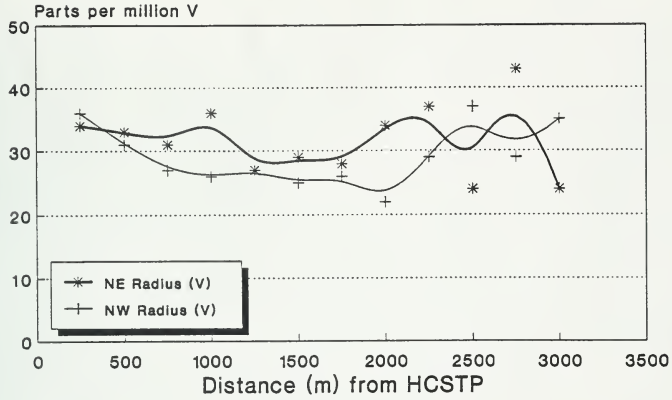
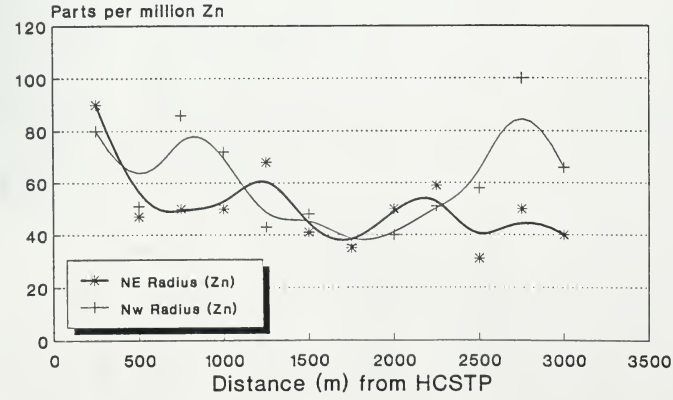
Pb in Surface Soil (0 - 5 cm)



HCSTP Soil Survey
Sb in Surface Soil (0 - 5 cm)



HCSTP Soil Survey
V in Surface Soil (0 - 5 cm)



HCSTP Soil Survey
Zn in Surface Soil (0 - 5 cm)